

Cosmic Origins Program Analysis
Group Report
NAC Astrophysics Subcommittee
Meeting – March 2016

Paul Scowen
(COPAG EC Chair)

COPAG EC Membership

Paul Scowen (Chair, APS Member) *

Lee Armus *

Daniela Calzetti ~

Dennis Ebbetts ~

Suvi Gezari *

James Green ~

Matt Greenhouse

Sara Heap ~

Chris Howk *

Mary Elizabeth Kaiser

Joseph Lazio

Pam Marcum

Mario Perez (Executive Secretary, Ex-Officio)

Kartik Sheth (Ex-Officio)

Susan Neff (COR Program Office, Ex-Officio)

Deborah Padgett (COR Program Office, Ex-Officio)

Arizona State University

Caltech

University of Massachusetts

Ball Aerospace

University of Maryland

University of Colorado

NASA/Goddard Space Flight Center

NASA/Goddard Space Flight Center

University of Notre Dame

Johns Hopkins

NASA/JPL

NASA/Ames

NASA HQ

NASA HQ

NASA/GSFC

NASA/GSFC

* New additions since last APS meeting

~ Members rotating off in Nov 2016

A word of thanks...

- Since the last APS meeting, the previous COPAG Chair, Ken Sembach, stepped down to assume his new role as Director of the STScI
- We would like to recognize and thank Ken for all his hard work over his years on the COPAG, especially during the last year on the Flagship question
- Thank you Ken!



COPAG Probe Mission Charge

- As part of the charge by Paul Hertz to the PAGs on the question of how to solicit input on Probe missions, the COPAG did the following:
 - Initiated a call for 2-page white papers
 - Analyzed the input received for both the science and mission capabilities called out
 - Worked with the ExoPAG and PhysPAG to compare inputs received to author a short joint statement
 - Wrote a report on the input received to submit to the APD
- Bottom Line: all three PAGs supported funded concept studies, but were concerned that \$100k each was not enough – also concerned that if a mission line was established that it be openly competed and not restricted by science topic like PSD New Frontiers

Probe Mission White Papers

- As a result of feedback received during the Flagship study, and in anticipation of the charge in January, the COPAG issued a call for 2-page white papers in December 2015
- We received a total of 16 white papers that covered a range of science, wavelength and instrument technology – posted online at: <http://cor.gsfc.nasa.gov/copag/probe-study.php>
- A summary table of the input was submitted to the APD and is also available on the COPAG website – the range of input received was taken to demonstrate that the community had a wide range of science and technological implementations that a Probe-class mission could enable
- Some authors took the approach of providing low risk, OTS mission designs, while others used much more cutting edge technology to adopt a higher risk profile

Range of Science

- Dark Ages – the first star and galaxy formation, reionization
- Recycling of matter between galaxies and the IGM
- Galaxy cluster formation and assembly
- Large scale structure of the ISM & stellar feedback
- Massive star evolution and death
- Census of massive star formation sites – survival rates for new stars and planets
- High resolution IR interferometer
- BAO study of 500 million galaxies – IR spectroscopy
- THz imaging and study of the earliest stages of molecular gas assembly

Range of Science, continued

- Use of the FUV to identify ISM diagnostics, protoplanetary disks, filamentary structure
- Use of the THz band to identify and study water content and formation

Non COR Science submitted:

- Space-based followup on LSST science
- Identification of asteroids and Kuiper Belt objects
- Understanding gamma ray bursts
- Hard X-ray monitor of the sky
- Large telescope assembly tech demo

Range of Capability

- Wavelength bands proposed: FUV, UV-visible, NIR, FIR, THz, Radio, X-ray
- Instrument types: spectrometers, imagers, interferometers
- Fields of view – generally large, from the smallest of 6' up to all-sky
- Cryogenic and ambient telescope and instrument temperatures

Implementation

- Range of payload masses: 1000-5000 Kg, most did not provide this number
- Orbit: several at Sun-Earth L2, a couple in GEO or Cislunar, most did not provide
- Cost: \$350M-\$2B – most not provided - the COPAG call did not hard-cap the costs at \$1B in an effort to see if allowing some overrun past the arbitrary \$1B number really enabled additional compelling capabilities – those that did exceed either had multiple instruments or were low- to non-heritage
- Basis: most were Center studies and parametric estimates, some heritage
- New technologies: radio signal processing, large x-ray arrays, electronics, power, data storage, GaN MCPs, modularized mirror deployment, large UV-vis focal planes, linear variable filters, slit generators, DMDs, inflatable reflectors, optical coatings

Summary of Conclusions

- The COPAG finds that there exists a wide range of community science goals that are both consistent with current National Academy priorities and that can be enabled with medium-class missions.
- In light of this fact, the Cosmic Origins community is in fact interested in supporting a line of probe-class missions using the alternatives presented by APD in the Charge to the PAGs.
- The COPAG finds that the work of preparing high quality white paper proposals to the 2020 Decadal Survey, for missions of this class, cannot be performed absent funding.
- The COPAG finds that the science community prefers a free and open solicitation process (such as a ROSES NRA) for provision of funding to enable the above work.
- Option #1 in the original Charge to the PAGs is therefore the preferred method for soliciting input on such a mission size to the 2020 Decadal Survey
- Option #2 attracted only modest levels of support

COPAG SAG/SIGs Status

- 9 SAGs have completed their work, delivered reports and have been closed
- 1 new SAG is being considered and is going through definition – enabling synergies between JWST and the rest of the CO astronomical portfolio
- 3 active SIGs – reports to follow
- Since the SIGs have already been engaged in analysis of compelling science at the Flagship level and the accompanying technology – we stand ready to pass on our findings to the respective STDTs

SIG 1 – FIR Science and Technology (David Leisawitz, GSFC, Chair)

- January 4, 2016 SIG meeting (Kissimmee) was very well attended
 - Good remote attendance, including international participation
 - Agenda:
 - Science talks
 - June 2015 workshop summary
 - Far-IR Surveyor study information
 - SIG leadership change
 - Presentations available at http://cor.gsfc.nasa.gov/copag/aas_jan2016/AAS2016-agenda-FIRSIG.php
- Received twelve applications to serve on new SIG Leadership Council
 - Current SIG leaders Paul Goldsmith, Dave Leisawitz, Pam Marcum to respond
 - Decision was put on hold until after Far-IR Surveyor STDT selection, now able to proceed
 - Aiming to increase community involvement through telecons and workshops

SIG 2 – UV-Visible Science and Technology (Paul Scowen, ASU, Chair)

- Workshop organizers continue to collate material to produce a summary report to be published as a paper. The goal is to have the report ready soon for use by the new LUVOIR and HabEx STDTs during the coming year.
- SIG2 face to face meeting at the recent AAS meeting in Kissimmee, FL focused on the question of Probe-class missions. The SIG discussed the impact of Probe-class missions on the range of compelling science explored at the workshop. The meeting notes were distributed to the SIG membership for their records.
- Looking forward, the SIG membership anticipates being responsive to the LUVOIR and HabEx STDTs and will inform them as appropriate when the SIG's input is solicited.
- The SIG will look to continue development of both science and technology portfolios with a particular view to outlining what technologies should receive focused effort through the annual PATR exercise.

Cosmic Dawn SIG (#3), Joe Lazio (JPL), Chair

AAS pre-meeting (January 4)

Title	Presenter
<p>Beyond the Horizon: What is Left to Learn After Hubble</p> <ul style="list-style-type: none"> • Deliberate effort to have multi-wavelength approach <ul style="list-style-type: none"> ➤ Need to expand to multi-messenger (e.g., gravitational waves from first black hole mergers) • Excellent means of stimulating cross-PAG engagement <ul style="list-style-type: none"> Interest piqued among those more commonly associated with PhysPAG (e.g., gamma-ray bursts) <p>Presentations at http://cd-sig.jpl.nasa.gov/</p>	
<p>Probing the EoR with Tomographic Intensity Mapping in the Far-IR through Millimeter</p>	<p>C. M. Bradford</p>

Cosmic Dawn Probe-class Mission Concepts

- A Probe-Class Opportunity for Far-IR Space Astrophysics (*Bradford et al.*)
- Probing the Dark Ages and Cosmic Dawn with Neutral Hydrogen (*Lazio et al.*)
- Concept for an all-sky low-energy gamma-ray observatory (ALLEGRO) (*Ulmer et al.*)
- Death of Massive Stars (DoMaS) Probe (*Roming et al.*)
- Deep Survey Telescope: Exploring the First Billion Years (*Hearty & Stahl*)
- Cosmic Dawn Intensity Mapper – A Probe Class Mission Concept for Reionization Studies of the universe (*Cooray et al.*)
- Terahertz Space Telescope: A Far-Infrared Surveyor of Cosmic Origins and Destiny (*Walker et al.*)

Cosmic Dawn SIG (#3)

“We have learned much in recent years about the history of the universe, from the big bang to the present day. A great mystery now confronts us: When and how did the first galaxies form out of cold clumps of hydrogen gas and start to shine---when was our ‘cosmic dawn’?”

New Worlds, New Horizons

SIG focuses on science cases, observations, and technology development needed to address this "great mystery" of Cosmic Origins.

- Membership is open to all.

To be added to the mailing list, please contact Joseph Lazio (Joseph.Lazio@jpl.nasa.gov)

- Website: <http://cd-sig.jpl.nasa.gov/>

- No APS actions being requested by the COPAG at this meeting

COPAG Future Activities

- Bi-weekly EC telecons will continue
- Planning for next steps workshops for all 3 SIGs during the next year
- Possible formation of JWST SAG/SIG
- Need to solicit replacement EC members to replace the 4 rotating off in November 2016
- Plan for COPAG dialogue at the Summer AAS meeting in San Diego
- Considering an informal COPAG get-together at the Summer SPIE meeting on Astronomical Technology in Edinburgh, Scotland